Meta-attitudes and the local formation of consumer judgments towards genetically modified food

Montserrat Costa-Font

The Centre for Research in Agro-Food Economics and Development (CREDA-UPC-IRTA), Edifici ESAB, Parc Mediterrani de la Tecnologia, Avda del Canal Olímpic s/n, 08860 Castelldefels, Spain Phone: +34-93-552-1213. Fax: +34-93-552-1121. E-mail:Montserrat.Costa-Font@upc.edu.

José M. Gil

The Centre for Research in Agro-Food Economics and Development (CREDA-UPC-IRTA), Edifici ESAB, Parc Mediterrani de la Tecnologia, Avda del Canal Olímpic s/n, 08860 Castelldefels, Spain Phone: +34-93-552-1210. Fax: +34-93-552-1121. E-mail: chema.gil@upc.edu

Abstract

This paper draws upon survey evidence from Spain to examine the causal relationship between attitudes towards science and attitudes towards Genetically Modified (GM) food. It employs structural equation modelling and explores this association by using sub-samples made of regional groups that have GM agriculture. Our results suggest specific behavioural mechanisms in explaining GM consumer attitudes involving attitudes towards science whilst medical and food applications appear to have no (or mild) significant connection in the formation of attitudes towards GM food. Finally, we find significant influence from age and previously characterized attitude in the formation of structural models. As one of the main limitations of this study it is worth mentioning the use of externally designed data that restricts the availability of existing constructs including “subjective knowledge" and consumer purchase intentions. This finding is important for policy makers in directing future communication strategies regarding scientific and technological applications. In explaining the mechanisms that explicate individuals’ acceptance of Genetically Modified (GM) food, one mechanism that has been largely ignored in the growing body of current research lies in the influence of “meta (wider) attitudes” such as the general attitudes towards science. Similarly, if attitudes are socially formed, we expect that regional self-interest will be determinant.

Keywords: GM food, attitudes towards science, regional self-interest, structural equation modelling, attitude formation.
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Introduction

Public opinion data reveals that European consumers seem to be persistently concerned about the use of genetically modified (GM) foods (Gaskell et al., 2006), which partially explains the Europeans moratorium on GM food. While Europeans seem to value some biotechnology applications, especially in medicine, food related applications exhibit different behavioural reactions. These reactions occur in spite of efforts to communicate their potential benefits. Indeed, after the commercialisation of Recombinant Bovine Sematoropin (BST) in 1994, a growth hormone, the US milk production from cows treated with BST increased from 15% in 1994 to 35% in 2001 (Chakraborty, 2005). Hence, consumer reactions in Europe might be driven by other features that overshadow potential benefits of GM food.

Consumer attitudes toward GM foods are found to be explained by a combination of risk and benefit perceptions associated with this new food generation (Moon and Balasubramanian, 2001 and 2004; Grunert et al., 2003; Onyango, 2004; Hossain and Onyango, 2004). However, general attitudes towards science and biotechnology have been disregarded as standing behind specific attitudes towards GM food (Lahteenmaki et al., 2002; Bredahl, 2001). Moreover, perceptions of risk and benefits are based on different elements such as a general attitude towards science, knowledge, trust, education and values, among others (Chen and Li, 2007; Saher et al., 2006). Hence, we hypothesize that meta-attitude, namely general attitudes towards science and technology, influence consumer acceptance of GM food.

In any case, attitudes toward GM food in Europe are widely divergent among countries and regions within countries. In fact, few regions have tried to establish GM-free zones using Article 19 of Directive 2001/18/EC, which allows authorities to specify conditions of consent including the protection of particular ecosystems/environments and/or geographical areas. This implies that such zones can be excluded from GM marketing consents if a scientific case is made demonstrating that the GM product in question poses a particular risk to the area. Therefore, it remains as an empirical question whether attitudes in GM free regions are different or, more specifically, follow a different structural causal model that those of GM producer regions.

Given the important policy implication of a better understanding of the behavioural mechanisms behind the acceptance of GM food, this study employs a structural equation approach to examine data from a representative sample of the Spanish population in 2001. Particularly, this article puts forward several hypotheses on the influence of general meta-attitudes (towards science and technology) underpinning behavioural explanations for consumer judgments of acceptance towards GM food. Second, given that Spain is a significantly heterogeneous country with GM free and GM producer regions, we examine whether the underlying structural model explaining GM food attitudes are different among respondents in these two regions. Finally, we explore a set of hypothesis regarding the influence of age, gender, and other related factors, as well as the reliability of survey respondents.

The structure of the article is as follows. Next section is devoted to the theoretical foundation of the models underlying attitudes towards GM food and a set of empirical hypothesis are outlined. Then, the third section explores the heterogeneity of GM attitudes and regulation. Section four is devoted to data and methods while section five reports the results. We end with some concluding remarks.

Theoretical framework

Perceived benefits and attitude towards science and technology

Understanding the influence of consumer attitudes toward science and technology – for instance attitudes toward nature or food neophobia - is important in order to define the perceived risk and benefits associated with technological applications (Chen and Li, 2007). Indeed, attitudes towards science and technology reflect inner respondents' belief in the ability of technological progress. Accordingly, gene technology can be conceptualised as one specific application of new technologies.

Hence, general attitudes toward gene technology are expected to be positively associated with technology acceptance (Bredahl, 2001).

In explaining the behavioural processes that explain GM food acceptance, another important determinant is information processing and regulation along with trust. Some survey research (Hoban, 1997) suggests that factual information increases consumer acceptance in the US and Japan. Moreover, information gathering in the area of GM foods have been linked to the perceived importance of the issue by Wilson et al. (2004). However, different information channels are more credible than others. In fact, many studies reveal that, regarding GM technology, consumer organizations, environmental groups and scientists appear to be more trustworthy than the biotech industry and government (Bredahl et al., 1998; Onyango et al., 2003; Savadori et al., 2004; Veeman et al., 2005). Similarly, theoretical research (Artuso, 2003) points out that the larger the expected net benefits of approved products and the more stringent the regulation is, the more confident the consumer might be on the safety of the science innovation. Furthermore, Grobe and Raab (2004) found in a referendum that took place in the US state of Oregon, on whether to label GM food, that the vast majority rejected labels due to its economic and alarmist impacts although there was a positive impact on trust building (McCullum, 2000). However, shopping, preparing and eating food is no longer only a matter of tradition and consumers direct experience, but are also a matter of mediated experience (Thompson, 1995).

Skepticism towards GM food is supported by evidence suggesting behavioral inhibition (Saher et al., 2006). Following Baker and Burnham (2001) and Onyango et al. (2003), the US consumers' 'attitudinal' segment can be partially explained by cognitive mechanisms that are not necessarily observed, such as individual values, or, as in our study, meta-attitudes. However, there is no agreement regarding the significance of these personal attributes on consumer's final attitude. Some scientists such as Frewer et al. (1998); Moon and Balasubramanian (2001, 2004) and Loureiro and Hine (2004), refer to the relationship between both moral and ethical considerations and consumer attitudes. By contrast, Vilella-Vila et al. (2005) concludes that moral issues appear not to be relevant in attitude formation with regards to GM food. Indeed, attitudes towards science and technology and attitudes towards nature are found to underpin individuals' trust towards scientific progress, where gene technology is a particular application

(Lahteenmaki et al., 2002; Bredahl, 2001). In other words, "*high regard towards nature makes people more suspicious towards gene technology" and "attitude to technology reflects respondents' belief in the ability of technological progress to solve the world's problems in the future"* (Lahteenmaki et al. 2002).

A strong relationship between an individual's feeling about the environment and their environmental attitude was observed by Fraj and Martinez (2007). Namely, people who are worried about pollution show a positive attitude towards the environment and are predisposed to act in an environmentally friendly manner. Moreover, attitudes towards gene technology are negatively associated with the general attitudes toward nature (Bredahl, 2001). In studies based on interviews, applying gene technology in food production has been regarded as unnatural and risky (Lahteenmaki et al., 2002). Moreover, (Loureiro and Bugbee, 2005) concluded that in the case of the tomato plant, attitudinal variables, such as concern about environment, play a negative and statistically significant role in explaining US consumer acceptance and WTP for different modifications. Finally, evidence that self-transcendence values like responsibility for nature are related to negative GM opinions have been reported by Bredahl (1999) and Dreezens et al. (2005).

Summing up, the hypotheses this article aims to test on this issue are the following (see figure 1):

H1: Consumers that reveal a positive general attitude towards science and technology are expected to perceive more benefits associated with science and technology.

H2: Consumers that reveal a positive general attitude towards the environment are expected to perceive fewer benefits associated with science and technology.

H3: Consumers that perceive more benefits associated with science and technology are expected to reveal a positive attitude towards biotechnology.

Insert figure 1 about here

Attitude and benefit perception of different biotechnological applications

Consumers do not perceive GM technology as being a one-dimensional skill. That is, although consumers reveal a positive attitude towards biotechnology, in general, this attitude is not the same for all applications. In fact, some studies, such as Gaskell et al. (2003); Grunert et al. (2001); Hossain et al. (2002, 2003); Savadori et al. (2004) argue that European and US consumers distinguish between different types of applications within biotechnology. They find that consumer attitudes and their consequent acceptance of a GM technology depend on the purpose of its use. More precisely, medical applications of GM are more frequently supported than agri-food applications. In any case, evidence on attitudes has become clearer in European countries, suggesting some reluctance towards the introduction of GM foods (Gaskell et al., 2003; Gaskell et al., 2004; Gaskell et al., 2006). Hossain et al. (2003), use a discrete choice model for fresh fruit and vegetables and find two main segments of consumers: those who are totally opposed to GM technology and those who would accept GM technology if there were some demonstrable benefits to the consumer. In addition, Loureiro and Bugbee (2005) observed that U.S. consumers are willing to pay a premium for *enhanced flavour*, followed by the *enhanced nutritional value* and *pesticide reduction* attributes.

Then our hypotheses are the following (see figure 1):

H4: Consumers that reveal a positive general attitude towards biotechnology perceive more benefits associated with GM food technology.

H5: Consumers that reveal a positive general attitude towards biotechnology reveal a positive attitude towards GM medical applications.

H6: Consumers that reveal a positive general attitude towards GM medical applications perceive fewer benefits associated with GM food technology.

Heterogeneity gm food attitudes: regulation in Spain

As stated in the literature, a further important relationship among the different stages of a consumer attitudinal process is their association with socio-economic and demographic attributes such as age, ethnicity, residence and income level, which are found to be directly related to consumers' attitudes towards GM food. These relationships are supported by Costa-Font and Mossialos (2005); Hossain et al. (2002 and 2003); Veeman et al. (2005); Noomene and Gil (2004) using mainly logit and probit models. Furthermore, Siegrist (2000), and Grimsrud et al. (2004) relate gender differences with benefit perceptions. These studies consistently find that women perceive lower benefits and are less likely to accept gene technology than men. Moreover, some of them revealed that young and middle age, less affluent and those who live in suburban areas are more concerned with GM food. On the other hand, Frewer et al. (1998) revealed no significant gender differences among respondents with high level of environmental concern. Therefore, this article has attempted to examine whether age and gender are important determinants of Spanish consumers GM food benefit perception. To this end, the full population has been segmented into two groups regarding gender (males and females) and into three groups regarding age (18-35, 36-56 and +56 years old).

We assume that:

H7: Age is a relevant individual attribute shaping consumers' GM food benefit perceptions. That is, older people trust less in new food technologies such as GM food.

H8: Gender is a relevant individual attribute shaping consumers' GM food benefit perceptions. Specifically, females trust less in new food technologies such as GM food.

On the basis of previous literature, population can be segregated in three main groups regarding GM food attitudes and intentions, namely: (i) anti-GM food or pessimistic, (ii) risk-tolerant or information searchers and finally (iii) GM-accepters or optimistic. Yet, different compositions of such groups within a specific society determines final country acceptance of GM food. On this basis it has become apparent that in the U.S. and some European countries such as Spain and Portugal among others, the population is found to be broadly more tolerant to GM food as compared to France or the Nordic population. Indeed, Huffman et al. (2007) observed that, prior subjective beliefs affect bidding behaviour of people for food items that might be genetically modified. Therefore, in this study we have segmented the sample in two groups based on consumers intentions towards GM food (willing to consume and not willing to consume), in order to show that previously defined attitudes towards a market product vary the process of perception of its associated benefits.

We assume that:

H9: previously characterized attitude towards GM food can alter the building process of GM food benefit perception.

Finally, in Spain, several regions have reacted to the authorization of commercially grown GM varieties, granted by the central government since 1998. The Parliament of Castilla la Mancha asked the central government to declare a moratoria on commercial GM crops until risk assessment is done for crops and food that contain GMOs (May 2000). In the Balearic Islands, the parliament expressed its worries for the introduction of GMOs and asked the central government not to authorize more GMOs until an international protocol guarantee their safety (February 2000). In Andalucía, the regional Parliament adopted in June 2000 a 5-year moratorium on trials of GM corps and asked the central government to do the same for all of Spain. The Basque country has issued a five-year blanket moratorium on GMOs. The Basque Government claims full powers on agricultural policy and can provisionally ban GMOs. The Basque country has also joined the European Network of GMO-free regions. There are also initiatives in Catalonia where several organizations are asking for a GM-free Catalonia. In particular, the most recent was carried out in August 2008 by an important Catalan social platform (*Som lo que sembrem*) composed by several organizations, such as the most important Catalan farmers union (Unio de Pagesos) among others. This platform has asked the regional government on March 9th to declare Catalonia GMO-free. Asturias declared itself GMO-free on 20/05/2004. The regional Parliament adopted a resolution that calls on the regional government to become part of the European Network of GMO-free regions in order to put pressure on the EU to take into account in its policy on GMOs. The agricultural and environmental strategies of the European regions and avoid the negative impacts of GMOs on the quality of farming products from Asturias and point out in the National Biosafety Commission the negative impact of GMOs on the production strategy of the farming sector in Asturias.

The Spanish crop area currently devoted to GMOs is summarized in table 1. Aragón, Castilla la Mancha and Catalunya are the major producers of GM maize in Spain. Thus, we segmented the sample between consumers living in GM free (Asturias, Baleares, Canarias, Galicia, Castilla-Leon, La Rioja, Murcia, Paìs Vasco and Valencia) and GM producer regions (Andalucía, Aragón, Castilla-la Mancha, Catalonia, Extrmadura, Madrid and Navarra) in order to detect if GMOs regional policy affect their GMF benefit perception process.

Insert table 1 about here

We assume that:

H10: The GM food benefit perception process differs between consumers of GM free and producer regions within Spain.

Spain is one of the few European countries that produce agricultural biotechnology products. Spain, unlike in other countries, the GM controversy has not been severe and has had a small influence (Vilella et al., 2005) in the earlier stages of implementation. Environmental organizations – which have headed the debate in other EU countries – have had a weaker role in Spain. However, from the mid–nineties, critics to GM have acquired a more prominent role and have been discussed in the Parliament. The governmental regulation bodies, namely the National Biosafety Commission and the public regulatory authorities, have responded to public concerns in certain circumstances that include the use of maker genes resistant to antibiotics. In 1997, commercialization of antibiotic resistant maker genes were banned in response to public debate as it were regarded as unnecessary (Tordt and Lujan, 2000). Indeed the dynamics of policy making in the European Union are not irrelevant for policy making in Spain. The question of consumer acceptance has been rather diffuse (Atienza and Lujan, 1997) and relies on important uncertainty on the future consumers reactions to new products that gives rise to precautionary measures e.g., some retailers avoid implicitly GM products.

Past studies have examined attitudes towards biotechnology and science in Spain. Most of them were very descriptive in nature (Atienza and Lujan, 1997; Lujan and Moreno, 1994). A deeper analysis of attitudes towards GM products is needed given the complexity of the issue. To this end, a multivariate approach is used in this article and is one of the main contributions. Results from this research allow us to derive some policy implications on how to manage the information that presumably affects the evolution of the market for GM food in Spain.

Data and research methodology

The Sample

In order to test the hypotheses mentioned in the two above sections, we have used the survey carried out by the Centro de Investigaciones Sociológicas (CIS) in 2001. The questionnaire concerns science and technology and its genetic engineering and biotechnological applications. The sample was composed by 2,492 respondents from Spain, proportionally distributed among the 17 regions. It is the unique survey, up to date, carried out on the field of biotechnology considering almost all Spanish regions. The sample is comprised of approximately 48% males and 52% women, either for the whole sample and or by regions. Ages range from 18 to 96 with almost uniform distribution. More than 90% of respondents have gone to school. From these, 6% do not end primary school; 25 % finish primary school; 22% finish “EGB”; 27% finish “secondary education”; 18% are “graduates”; finally 1% has postgraduate studies and 1% other studies.

Almost half of the respondents are solely responsible for household income. Moreover, half are working, almost 20% are pensioners, 20% do not work, around 5% are unemployed and another 5% are students

Measures

We have considered, as the literature points out, that responses range from agree to disagree going through some uncertainty threshold (Gaskell et al., 2004; Gaskell et al., 2006; O'Connor et al., 2006). Therefore, "don't know" answers are classified as "undecided or indifference" which are accordingly placed somewhere between acceptance and rejection (Costa-Font and Mossialos, 2007). All questions except for general attitudes toward science and the environment were measured on a 3-level Likert scale, where "tend to agree" responses are coded as an ordinal value of 1, "undecided or indifference" by 2 and finally, "tend to disagree" by ordinal value 3. Similarly, questions regarding general attitudes toward science and the environment were measured on a 4-level Likert scale, from a lot to nothing. Our selection of CIS questions are shown in table 2.

Insert table 2 about here

Analytical Procedures

Structural equation modelling has been used in this study in order to arrange the decision making process. Indeed, the structural regression (SR) model has been tested following a two-step modelling approach (Anderson and Gerbing, 1988), where we first define an acceptable confirmatory factor analysis (CFA) and next an adequate SR model.

Following Jöreskog and Sörbom (1996), we specified a Structural Equation Model which consists of three main types of relationships. First, a measurement model is identified after performing confirmatory factor analysis. The outcome relates observed indicators with the exogenous latent variables;

$$x = \Lambda_x \ \xi + \delta \qquad (1)$$

where x, is a $q \times 1$ vector of observed exogenous or independent variables, Λ_x is a $q \times n$ matrix of coefficients of the regression of x on ξ, ξ is an $n \times 1$ random vector of latent independent variables and δ is a $q \times 1$ vector of error terms in x.

On the other hand, observed indicators are related with the endogenous constructs;

$$y = \Lambda_y \ \eta + \varepsilon \qquad (2)$$

where y, is a $p \times 1$ vector of observed endogenous or dependent variables, Λ_y is a $p \times m$ matrix of coefficients of the regression of y on η, η is an $m \times 1$ random vector of latent dependent variables and ε is a $p \times 1$ vector of measurement errors in y.

A third equation defines the structural model, which specifies the causal relations that exist among the latent variables, describing its causal effects and assigning the explained and unexplained variances (Jöreskog and Sörbom, 1996).

$$\eta = \mathrm{B}\,\eta + \Gamma\,\xi + \zeta \qquad (3)$$

where B is a $m \times m$ matrix of coefficients of the η variables in the structural relationship, Γ is a $m \times n$ matrix of coefficients of the ξ - variables in the structural relationship, and ζ is a vector of errors.

The model assumes that the ε is uncorrelated with η, δ is uncorrelated with ξ, and ξ is uncorrelated with ξ. Moreover, ξ, ε and δ *are* mutually uncorrelated. Furthermore, the covariance matrices of the model are defines as:

Cov (ξ) = $\Phi \quad (n \times n)$; Cov (ε) = $\Theta_\varepsilon \quad (p \times p)$; Cov (ξ) = $\Psi \quad (m \times m)$ and Cov (δ) = $\Theta_\delta \quad (q \times q)$.

This study uses ordinal data, where the scale is considered as thresholds of the continuous variables (Jöreskog and Sörbom, 1996). Correlations among ordinal variables are called polychoric correlations, which are theoretical correlations of the continuous version (Jöreskog and Sörbom, 1996). In order to perform the analysis, we use the General Weighted Least-Squares (WLS) method instead of Maximum likelihood (ML), since both the data present a non-normal distribution and because ML does not allow us to employ the weight matrix required for the analysis, which is the inverse of the estimated asymptotic covariance matrix, W, of the polychoric correlations (Kline, 2005).

$F(\theta) = (s - \sigma)' W (s - \sigma)$ (4)

where s' is a vector of the elements in the lower half of the covariance matrix S of order $k \times k$ used to fit the model to the data, σ' is the vector of corresponding elements of $\Sigma(\theta)$ reproduced from the model parameters θ, finally W^{-1} is the positive definite matrix of order $u \times u$ where $u = k(k+1)/2$. The WLS function is the weighted computation of the square residuals (Barrio and Luque, 2000).

We will assess the goodness-of-fit for the model by analysing factor loadings that relate each indicator with the constructs. Reliability will be measured by means of composite reliability and Cronbach'α. Moreover, the extracted validity for each construct will be also measured (Hair et al., 1999).

Since cross group comparisons were performed, the level of invariance will already be measured. In this case, the confirmatory factor analysis will be defined by means of Multi-Sample analysis (Steenkamp and Baumgartner, 1998). For Multi-Sample analysis it is assumed that equations (1), (2) and (3) holds in each group. Considering a set of G groups, the model for group g is defined by the parameter matrices: $\Lambda_y^{(g)}$, $\Lambda_x^{(g)}$, $B^{(g)}$, $\Gamma^{(g)}$, $\Phi^{(g)}$, $\Psi^{(g)}$, $\Theta_\varepsilon^{(g)}$, $\Theta_\delta^{(g)}$, where the subscript (g) refers to the g-th group, $g = 1,2,...,G$ (Jöreskog and Sörbom, 1996). Each of these matrices may contain fixed, free and constrained parameters as before. To estimate all the models simultaneously, the following fit function is minimized,

$$F = \sum_{g=1}^{G} \left(N_g / N \right) F_g (S^{(g)}, \Sigma^{(g)}, W^{(g)}), \qquad (5)$$

where, F_g is the fit function (4), N_g is the sample size in group g and $N = N_1 + N_2 + ... + N_G$ is the total sample size; $S^{(g)}$ and $\Sigma^{(g)}$ are the sample and population covariance matrices in group g, and $W^{(g)}$ is the weight matrix for group g.

Once the parameters have been estimated, the “configual” or “pattern” invariance is considered. This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model is the same for the different segmented groups (Steenkamp and Baumgartner, 1998). In this case, similar but not equal latent variables are presented in the different groups. We have to note that, “configural” invariance does not indicate that people in different groups respond to the same items in the same way (Steenkamp and Baumgartner, 1998). However, it allows us to explore the basic structure of the construct cross-groups.

As a second step, full or partial metric invariance has to be satisfied because the scale intervals of the latent constructs have to be the same or at least comparable across groups. In other words the following condition must be fulfilled.

$$\Lambda_y^{(1)} = \Lambda_y^{(2)} = \ldots = \Lambda_y^{(G)}, \textit{ and } \quad \Lambda_x^{(1)} = \Lambda_x^{(2)} = \ldots = \Lambda_x^{(G)}$$

This allows us to examine structural relationships with other constructs cross-groups.

Regarding the structural model, we begin with an assessment of the estimated parameters in the structural equations (Hair et al., 1999). We proceed with estimating the reliability coefficients of each equation and the associated correlation matrix among constructs examined in our model (Barrio and Luque, 2000). Finally, diagnostic parameters such as Chi square (X^2); Root Mean Square Error of Approximation (RMSE); Goodness of Fit Index (GFI); the Adjusted Goodness of Fit Index (AGFI); the Comparative-Fit-Index (CFI); the Normed-Fit-Index (NFI) and the Non Normed-Fit-Index (NNFI) will be also considered as indicators of the model goodness-of-fit for the CFA and the SR model.

Results

Descriptive Analysis

Before empirically testing the theoretical structural model defined in this study, some descriptive results from the survey are provided. First, some questions regarding science and technology are evaluated. Interestingly, there is some ambivalence in public opinion on science and technology. One the one hand, 61% of respondents agree that science and technology is a source of risk, which is characterized as “skepticism on science”. However, about 63% of the respondents also trust in science for solving current and future problems. Moreover, the Spanish society seems to be divided into three groups regarding their perception of science (see figure 2). This division has been already detected by Gaskell et al. (2003, 2004, 2006) and Onyango et al. (2004): 49% of the respondents answered that science will be beneficial in the next 20 years (“science supporters”), 31% just opposite (“science reluctance”) and 20% either don’t know or don’t answer (“indifferentist”). This last group is relevant and should have something to do with the lack of information already stated. The final consumer decision of “undecided” is a key element for social acceptance or reluctance of science advances.

Insert figure 2 about here

Although 65% of the respondents are interested on science, only 37% are self-defined as “informed”, while, 60% describe themselves as not well informed. These percentages display evidence of a lack of compressible information available on science and technology for Spanish citizens. A similar situation takes place for environmental issues. Around 74% of respondents reveal to be interested, but only 46% consider themselves as “informed”, while 50% declared they are not well informed.

Looking at regional differences, Aragon, Canary Islands, Catalonia and Madrid are the most interested in science and technology – with more than 70% of respondents interested. Regions on the opposite side include Andalusia, Asturias, Cantabria, Extremadura and the Bask Country. Likewise, public “subjective knowledge” on science and technology is only relevant for two regions, Rioja and Navarra. Catalonia, Aragon, Valencia and Madrid are near the average (40%) of respondents feeling well informed about science and technology while in the rest the percentage rages from 20 to 30%.

The last part of the questionnaire aims to examine Spanish public perception towards biotechnology and genetic engineering. First, general public subjective knowledge on this technologic application seems to be lower than on science and technology taken as a whole. Results indicate that only 18% of the sample feels well informed about genetic engineering or biotechnology. These results are consistent with previous studies in Spain, as those by Martinez et al. (2004) ; Noomene and Gil et al. (2004) ; Vilella-Vila et al. (2005), among others. Moreover, these authors also state that the Spanish population has not made a significant effort to be informed. As well as for science and technology, the region with major "subjective knowledge" is Rioja – where almost 60% of the sample feel well informed about genetic engineering and biotechnology- followed by Cantabria – with almost 30% - and Navarra – with more than 26%.

Risk perception of damages derived from biotechnology and genetic engineering on people and environment is visibly important for Spanish society. Almost 50% of the sample considers these applications as dangerous for people and more than 50% consider them a danger for the environment. This important level of risk perception seems strange as many people who perceive biotechnology as a risky activity admit to be under-informed on the topic.

In spite of this general attitude, some differences exist depending on the type of application. In general, people tend to positively value those applications with major direct benefits to the public, as it happened when evaluating science and technology in broad sense. As can be observed in table 3, people mainly value medical applications, followed by environmental applications and agricultural applications. In addition, no main regional differences on perceptions and use of genetic engineering applications appear to exist. Respondents in Aragon give high value to agricultural applications, (average value of 8). This can be partially explained by the fact that it is one of the main producer regions of GM maize.

Insert Table 3 about here

Table 4 shows that respondents feel alarmed about these products, and find them unnecessary and unnatural. There are no significant regional differences, in relation to this question: However, Asturias shows a clearer pattern of GM food tolerance, as items considering GM food as beneficial, and with acceptable risks, get an average score of 6.

Insert Table 4 about here

Measurement Model (Confirmatory Factor Analysis)

Following the methodological approach described in section 3, the first step of the study is to carry out a confirmatory factor analysis for the whole set of constructs considered in the theoretical model: 1) consumers approach towards science and technology; 2) consumers approach towards the environment; 3) perceived benefits of science and technology; 4) attitudes toward biotechnology; 5) attitudes toward GM medical applications; and 6) Perceived Benefits of GM food, assuming all errors to be uncorrelated. It has been performed using both a single full population analysis and some Multi-Group Analyses. More precisely, in this study the sample has been segmented by: a) consumer intentions towards GM food; b) GM-free and GM producer regions; c) gender; and d) age. The confirmatory factor analysis with all indicators resulted suitable for both the full sample and Multi-Group Analyses. The correlation matrix among all variables for the full model is presented in Table 5.

Insert Table 5 about here

The main parameters to test for the robustness of the constructs, following Hair et al. (1999) and Kline (2005), appear to show acceptable results for the full sample as well as for the Multi-Sample models, as shown in tables 6 to 10. Indeed, the reliability of factor loadings for all constructs are above 0.5 and the t-values associated with the loadings are all significant ($P<0.001$), implying a satisfactory convergent validity (Olsen, 2003). Four additional parameters are important in examining the internal consistency of the model, which include composite reliability (which must be > 0.7), internal consistency reliability, measured by Cronbach's α, (which must be around 0.7), extracted validity (which must be >0.5) and discriminant validity (correlations among constructs < 0.85) (Hair et al., 1999; Bagozzi and Yi, 1988). For every construct, all composite reliabilities are greater than 0.7 and all Cronbach's α are around 0.7, thus we can say that reliability is acceptable. Regarding the variance extracted, it is higher than 50% in all cases. Finally, since the correlations among latent factors do not exceed 0.85, in any case, it can be stated that discriminant validity has been accomplished too.

Insert Tables 6 to 10 about here

The model meets the widely accepted goodness of fit standards for the Full sample confirmatory model and for the Multi-Sample confirmatory models (configural invariance) indicating that the conceptual model satisfactory fits the data, (see also tables 7 to 11). It must be pointed out that although the chi-square was significant, it is highly affected by sample size (Kline, 2005). Therefore, alternatively goodness of fit criteria were considered. For the full sample (see table 7), the Root Mean Square Error of Approximation (RMSEA) is 0.06, which is well under the 0.5-0.8 limit interval offered by Hair et al. (1999) and Kline (2005). The goodness-of-fit index (GFI) was 0.98, the adjusted Goodness of Fit Index (AGFI) was 0.97, the Comparative-Fit Index (CFI) 0.95, the Normed-Fit Index (NFI) 0.94 and the Non-Normed Index (NNI) 0.94, all were greater than 0.90 as suggested by Marcoulides and Schumacker (1996) and Chen and Li (2007).

Finally, the results for the levels of invariance, regarding the different Multi-Group Confirmatory Factor Analyses, indicate that configural invariance is accomplished across all segmented groups (see tables 8 to 11). This model is estimated with science as the baseline model against other models (Steenkamp and Baumgartner, 1998). Although the chi-square was significant ($p<0.001$), the RMSEA, the GFI, AGFI, CFI, NFI and the NNFI were above the commonly recommended levels. Moreover, all factor loadings were highly significant for all Multi-Group Analyses, and standardized factor loadings exceeded 0.6 in all cases. Therefore, it can be stated that the model exhibits configural invariance across age, gender, consumer intentions and GM regional regulation groups. This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model are the same for the different segmented groups (Steenkamp and Baumgartner, 1998). That is, the model of interest fits across the groups, that is, the basic structure of each construct fits across groups; however, the unknown parameters (latent variables) of the model are assumed to be similar but not identical across the groups.

A stronger test of invariance (the metric invariance) has also been analyzed. This analysis examines whether respondents of the different groups respond to the items in the same way by allowing us to examine structural relationships among constructs (Steenkamp and Baumgartner, 1998). Results indicate that the hypothesis of full metric invariance, that is, factor loadings being invariant across groups, is supported only for gender. As table 8 shows, there is a non significant increase in chi-square between the model of configural invariance and the model of full metric invariance ($\Delta\chi^2(19) = 16.03, p > 0.10$). Moreover, other goodness of fit criteria such as RMSEA are also adequate. Therefore, we can support full metric invariance for the 19 loadings.

For the other three Multiple-Group analyses, a significant increase in the chi-square statistic between the model of configural invariance and the model of full metric invariance was detected (Age segmentation: $\Delta\chi^2(38) = 134.70, p \prec 0.001$; Consumer intentions: $\Delta\chi^2(19) = 151.98, p \prec 0.001$; GM regional policy: $\Delta\chi^2(19) = 114.4, p \prec 0.001$). The analysis of the Modification Indices (MIs) shows that five, four and six of the nineteen factor loadings for age, consumer intentions, and regional GM policy, respectively, are responsible of the model lack of invariance. Let us consider each of these three segmentations.

In relation to the age segmentation factor loading of items X2, X9, X10 and X18 (see table 2 to name the items) were lower in Age 18-36 than in the other age groups. In addition, X8 was higher in Age 36-56 than in the other age groups. We set free these factor loadings to test partial metric invariance. Table 9 shows the statistical results of this model. We can see that the increase in chi-square between the configural invariance model and the metric invariance model is not significant ($\Delta\chi^2(28) = 46.3 p \geq 0.01$), moreover, other goodness of fit values such as RMSEA are also adequate. Therefore, we can support partial metric invariance with five of the 19 invariance constrains relaxed.

As can be observed in table 10 factor loadings of X1, X8, X14 and X18 in the consumer intentions segment were lower in the not willing to consume GM food segment than in the other group. We also observe that the increase in the chi-square statistic between the configural and metric invariance models is not significant ($\Delta\chi^2(19) = 23.56 p \geq 0.10$). As a result, we can support partial metric invariance with four of the 19 invariance constrains relaxed.

Finally, for the regional GM policy segmentation, factor loadings of X4, X5, X8, X15 and X16 (see table 2 to name the items) were lower in the GM producer regions group than in the other group. In addition, X19 (see table 2 to name the item) was lower in the GM free regions. Thus, we set free these factor loadings to test partial metric invariance. Table 11 shows the statistical results of this model. Contrary to the other two cases, in this case there is a significant increase in the chi-square statistic between the configural and the metric invariance models ($\Delta\chi^2(13) = 54.6 p < 0.01$). As a consequence, even though other goodness of fit values such as RMSEA are adequate, we cannot support partial metric invariance.

To sum up, we have obtained a common pattern among all different segments regarding the adequacy of the used constructs. That is, the structure of each construct is equal across groups. However, a perfect comparison of the structural relationships among groups can only be ensured for gender segmentation on the basis of our diagnostic tests. In any case, valid cross-group comparisons of the structural model can be conducted even when the ideal of full invariance is not realized (Steenkamp and Baumgartner, 1998). Therefore we can clearly compare among gender, age and consumption intentions groups since at least partial metric invariance has been checked. On the contrary, the comparison of structural relations between regions with different GM policies must be analyzed in further analysis due to its lack of metric invariance.

Structural Model

When testing the structural relations of the models using a Structural Equation Model we find that a satisfactory fit has been obtained for all models (table 11). Figure 3 shows the path diagrams obtained for the full sample model. All hypotheses except hypothesis 6 are with paths significant at $p = 0.001$ level and therefore supported. This means that consumer's attitude towards science and technology does have a positive and important influence on its benefit perceptions of science and technology ($\beta = 0.5$). The opposite takes place when considering attitudes towards the environment ($\beta = -0.21$). The estimation of path coefficients from perceived benefits of science and technology to attitudes towards biotechnology reveals that there is a positive relation among these two constructs ($\beta = 0.73$). Finally, hypothesis 4 and hypothesis 5 that assume a better acceptance of GM medical applications and major GM food benefit perception if consumers reveal a positive attitude towards biotechnology were also supported ($\beta = 0.45$ and 0.68 respectively). In contrast, a negative relation among attitudes towards medical applications and GM food benefits perception was not supported (hypothesis 6).

Insert figure 3 and Table 11about here

If we examine Spanish consumers' heterogeneity by age (figure 4), we observe that younger respondents tend to be more homogenous than the full population. However, the behaviour of the oldest group is different. As can be observed in figure 4, for this segment there is a weaker relationship of attitudes towards science and technology and benefits perception. In addition, there is a positive relationship between attitudes regarding the environment and science and technology perceived benefits. Hypothesis 3, 4 and 5 have the same sign and level of significance as other groups, but the path coefficient is lower, especially for hypothesis 4 and hypothesis 5. Finally, the negative association between attitudes towards GM medical applications and GM food benefits perception (hypothesis 6) is not supported as it was the case in the other age groups, as well as in the full sample. In conclusion, older people (+56 years old) understand benefits of science and technology differently than the rest of respondents, especially regarding its relation towards the environment. However, the behavioural process that goes from science and technology benefit perception to GM food benefit perception is similar for the entire sample no matter the age of respondents.

Insert figure 4 about here

Figure 5 shows the main relationships concerning consumer intentions. Regarding to hypothesis 1, 3, 4 and 5, there is a clear agreement among groups, that is: (hypothesis 1), a positive approach towards science and technology has a positive impact on science and technology benefit perception with a path of about 0.5; hypothesis 3, attitudes towards biotechnology rely on benefit perception of science and technology, more for people willing to consume GM food; either hypothesis 4 and 5 were supported for the two groups. That is, attitudes towards GM medical applications depend on consumers attitudes towards biotechnology with similar path coefficients and significance for the two segmented groups. However, GM food perceived benefits depend on attitudes towards biotechnology with a major path coefficient for consumers willing to consume GM food than for consumers not willing to consume GM food. Finally, hypothesis 2 and hypothesis 6 were significant for only one of the two segmented groups. Explicitly, a positive approach towards the environment has a negative impact on science and technology benefit perception only for people not willing to consume GM food (hypothesis 1). Furthermore, positive attitudes towards GM medical applications were considered to have a negative influence on GM food perceived benefits for the group willing to consume GM food. Therefore, we can conclude that attitudes towards biotechnology rely more on benefit perception of science and technology for people willing to consume GM food. Moreover, a positive approach towards the environment has a significant negative impact on science and technology benefit perceptions for people not willing to consume GM food. And parallel, attitudes towards biotechnology have a major influence on GM food perceived benefits for consumers willing to consume GM food and attitudes towards medical applications are significantly negative related to GM food perceived benefits only for the group willing to consume GM food.

Insert figure 5 about here

Although metric invariance was not supported, we compared the structural model results among Spanish GM free and producer regions. Indeed, all hypotheses were significant for the two groups. Moreover, hypothesis 1, 3, 4 and 5 present similar path coefficients among groups- see figure 6. Dissimilar, the path coefficient of hypothesis 2 is bigger for the GM free group. That is, respondents from GM free regions reveal a more important negative relation between consumers' positive approach towards the environment and consumers benefit perception towards science and technology. Finally, an important difference in hypothesis 6 exists among groups. That is, respondents from GM producer regions reveal a negative relation between positive attitudes towards GM medical applications and GM food benefit perception, opposite the positive relations revealed for consumers of the GM free regions. Indeed, this comparison must be cautiously considered since we cannot ensure that the structural relations among the Latent Variables that we are relating are comparable among the two groups.

Insert figure 6 about here

Finally, gender heterogeneity is analyzed, see figure 7. Minor heterogeneity was detected for this segmentation. All paths present the same singe and significance for the two groups. Moreover, almost all groups have similar path coefficients but for hypothesis 1 and hypothesis 2 that females reveal a bigger coefficient. That is, the positive and negative influence that science and environmental approaches have on science and technology perceived benefits is more important for females than for males.

Insert figure 7 about here

Conclusion

The motivation of these articles is grounded on exploring the influence of meta-attitudes in explaining specific consumer judgments of GM food. In this article, we test the causal and empirical validity of a behavioural mechanism to explain evidence of scepticism towards Genetically Modified (GM) food. Consumer reactions to GM food appear to demonstrate a simultaneous endorsement of risk and benefit perceptions (Pidgeoen et al., 2005).

From exploring the causal empirical model, we found that individuals' interest and information towards either science or the environment are key factors in defining their perceived benefits associated with scientific and technological applications, supporting hypothesis 1 and hypothesis 2 of the analysis. This finding is important for policy makers in directing future communication strategies regarding scientific and technological applications. Results show that a positive approach towards science and technology is positively related with science and technology benefit perception (hypothesis 3). This result exhibits the relation among what is know as "subjective knowledge" and attitude towards a behavior, stated by some studies such as Lusk et al. (2004). Indeed, "subjective knowledge" depends on an individual's general values and this makes people search information from diverse sources - consumer organisations, environmental groups and scientists among others. Therefore, more effective risk-benefit communication strategies are needed regarding new scientific applications, such as GM food.

This study also supports a link between positive attitudes toward biotechnology and the perception of benefits associated to either GM medical applications (hypothesis 4) or food applications (hypothesis 5), consistent with earlier research. However, consumers do not perceive GM technology as being a one-dimensional skill. Therefore, no significant relation has been detected between the acceptance of GM medical applications and GM food applications (hypothesis 6). Consequently different risk-benefit communication strategies must be developed for each GM application.

In addition to the behavioral mechanism, this study also considers the relevance of individual values and social elements in constructing this mechanism. For that, a Multi-Sample analysis has been performed. We segmented the sample by: consumer intentions towards GM food; consumer of GM-free and GM producer regions; gender and age. Results indicate that for the Multi-group analyses, the measurement instruments are at least partially invariant for almost all cases – not for GM-free and GM producer regions. Nevertheless, valid cross-group comparisons can be conducted even when full invariance is not realized (Steenkamp and Baumgartner, 1998).

First of all, no main gender heterogeneity was detected in this study (hypothesis 8), except for the female group, which was more positively and negatively influenced by science and environment approaches, respectively, on science and technology benefit perceptions. Regarding to respondents age (hypothesis 7), two main behavioral mechanism groups were defined: less than 56 and more than 56 years old. The main difference is the positive, instead of negative, relations of consumers approach towards the environment and its perceived benefits of science and technology. That is, older people who are more interested and knowledgeable about nature do perceive benefits associated to science and technology, which is in contrast to younger people. Furthermore, some heterogeneity was detected regarding consumer previous characterized attitude towards GM food (hypothesis 9). Finally, no main results can be reported regarding the structural relations of GM free and producer regions since measurement invariance among these groups is not supported (hypothesis 10).

The model developed in this study examines only one side of the complex process that underpins individuals' purchase intentions towards GM food. An extension of the model definition could be undertaken with the introduction of additional latent variables such as, GM food *subjective knowledge*, labelling information, risk attitudes, social behaviour regarding GM food and purchase intentions towards GM food. Although the model developed in this study highlights the relevance of general values (meta-attitudes) in shaping individuals behaviour, our findings call for a future research to explore alternative explanations. As one of the main limitations of this study it is worth mentioning the use of externally designed data that restricts the availability of existing constructs including *subjective knowledge* and consumer purchase intentions.

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Table 1. Spanish area devoted to GM maize production by regions.

Year	1998	1999	2000	2001	2002	2003
Andalucía	780	2.800	1.500	450	1.800	2.089
Aragón	11.500	7.300	9.000	4.250	9.200	12.905
Asturias	0	0	0	0	0	6
Baleares	2	2	26	0	30	2
Castilla la Mancha	4.500	6.800	5.650	870	4.150	8.171
Castilla León	200	360	270	0	0	0
Catalunya	1.700	3.000	4.500	3.250	5.300	5.278
Extremadura	1.000	2.500	2.500	600	1.500	1.633
La Rioja	25	30	30	0	0	0
Madrid	660	1.560	1.970	1.940	780	678
Navarra	1.760	300	220	80	500	1.401
Valencia	190	300	150	100	20	1
Total	22.317	24.952	25.816	11.540	23.280	32.164

Source: MAPA

Table 2. List of indicators used for each construct.

Construct	**Indicators**
Approach towards science and technology (***C1***)	***X1:*** I am interested in science and technology ***X2:*** I feel well informed about science and technology
Approach towards the environment(***C2***)	***X3***: I am interested in the environment ***X4***: I feel well informed about the environment
Perceived Benefits of science and technology (***C3***)	***X5***: In the next twenty years, science and technology development will be positive for the world. ***X6***: In the next twenty years, science and technology benefits will overcome its risks. ***X7***: The problems of current technology will be solved by future technology. ***X8***: Science and technology have made this world dangerous.
Attitudes towards biotechnology and genetic engineering (***C4***)	***X9***: Genetic engineering have contributed to increase human quality live. ***X10***: Biotechnology have contributed to increase human quality live ***X11***: Biotechnology and genetic engineering advances are dangerous for humans. ***X12***: Biotechnology and genetic engineering advances are dangerous for the environment.
Attitudes towards genetic engineering medical applications (***C5***)	***X13***: Genetic engineering is totally acceptable for identify genetic illness in humans. ***X14:*** Genetic engineering is totally acceptable for application in new medical treatments.
Perceived Benefits of GMF (***C6***)	***X15***: The existence of GMF will benefit almost all population. ***X16***: Risks associated to GMF are acceptable. ***X17***: Although GMF have benefits this product is a danger for nature. ***X18***: The idea of GMF frightens me. ***X19***: GMF do not raise any danger for future generations.

Table 3 Public opinion on the genetic engineering applications

Question	mean	s.e
To develop crops resistant to frozen and “plagas”.	6.37	0.072
To develop cattle “engordar” fater.	1.58	0.052
To develop bacterium for cleaning up black “marea”	7.72	0.059
To detect people hereditary diseases	8.36	0.044
To apply new medical treatments	8.45	0.044

Question: how you would value the use of genetic engineering for the following purposes? (Note: 0 “totally disagree” and 10 “totally agree”)

Table 4. Public opinion on GM food

Question	mean	s.e
The existence of GM will benefit most of the population	3.55	0.071
Risks associated with GM food are acceptable	3.50	0.067
Although some benefits are associated to GM food, these are unnatural	7.50	0.057
The idea of GM food alarms me	6.50	0.066
The existence of GM food is not dangerous for future generations	3.02	0.069

Question: Now I will read you some opinions on the existence of GM food, and would like you to tell me the degree of agreement or disagreement with them. (Note: 0 “totally disagree” and 10 “totally agree”)

Table 5 Correlation matrix among indicators (Full population)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.00																		
X2	0.66	1																	
X3	0.60	0.44	1																
X4	0.47	0.72	0.65	1															
X5	0.28	0.20	0.10	0.13	1														
X6	0.16	0.16	0.02	0.07	0.67	1													
X7	0.18	0.20	0.04	0.14	0.46	0.47	1												
X8	-0.09	-0.13	0.00	-0.06	-0.33	-0.40	-0.28	1											
X9	0.21	0.16	0.13	0.11	0.26	0.28	0.21	-0.18	1										
X10	0.28	0.27	0.17	0.19	0.33	0.30	0.25	-0.25	0.64	1									
X11	-0.09	-0.07	0.01	-0.05	-0.24	-0.37	-0.28	0.38	-0.36	-0.26	1								
X12	-0.05	-0.04	0.07	-0.02	0.21	-0.34	-0.29	0.36	-0.26	-0.24	0.84	1							
X13	0.24	0.21	0.17	0.21	0.28	0.22	0.27	-0.09	0.25	0.25	-0.27	-0.25	1						
X14	0.21	0.19	0.14	0.16	0.28	0.25	0.30	-0.12	0.26	0.25	-0.32	-0.29	0.92	1					
X15	0.13	0.13	0.03	0.11	0.24	0.31	0.29	-0.25	0.28	0.30	-0.43	-0.43	0.28	0.30	1				
X16	0.09	0.13	-0.01	0.06	0.22	0.28	0.25	-0.26	0.27	0.27	-0.39	-0.38	0.20	0.26	0.65	1			
X17	0.00	0.02	-0.05	-0.02	0.14	0.24	0.23	-0.18	0.22	0.23	-0.36	-0.35	0.15	0.17	0.52	0.62	1		
X18	-0.01	-0.05	0.10	0.00	-0.04	-0.16	-0.09	0.38	-0.11	-0.20	0.28	0.29	0.04	0.02	-0.46	-0.48	-0.35	1	
X19	-0.07	-0.11	0.07	-0.03	-0.13	-0.22	-0.18	0.41	-0.17	-0.21	0.40	0.37	-0.06	-0.05	-0.49	-0.51	-0.43	0.62	1

Table 6. Reliability of the standardized Confirmatory Factor Analysis (Full population).

Construct	Indicators	Standardized loadings (*t*-Value)	Composite reliability (Variance extracted)	Goodness of fit parameters
C1	***Cronbach's α***	0.73	0.89 (0.80)	χ^2 = 1263.14
	X1	0.88 (62.63)		df = 137
	X2	0.91 (74.43)		p = 0.00
C2	***Cronbach's α***	0.72	0.90 (0.82)	
	X3	0.87 (51.71)		
	X4	0.94 (64.60)		
C3	***Cronbach's α***	0.64	0.83 (0.50)	$RMSEA$ = 0.06
	X5	0.77 (43.42)		
	X6	0.84 (55.34)		GFI = 0.98
	X7	0.66 (34.11)		
	X8	-0.69 (34.94)		$AGFI$ = 0.97
C4	***Cronbach's α***	0.66	0.89 (0.59)	
	X9	0.70 (39.93)		
	X10	0.74 (43.49)		CFI = 0.95
	X11	-0.94 (90.06)		
	X12	-0.89 (74.76)		$NNFI$ = 0.94
C5	***Cronbach's α***	0.88	0.96 (0.93)	
	X13	0.97 (47.51)		
	X14	0.96 (50.76)		NFI = 0.94
C6	***Cronbach's α***	0.75	0.85 (0.65)	
	X15	0.85 (61.93)		
	X16	0.85 (65.80)		
	X17	0.72 (42.71)		
	X18	-0.71 (36.82)		
	X19	-0.80 (49.87)		

Note: RMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Table 7. Reliability of the standardized Confirmatory Factor Analysis (Gender segmentation)

Construct	Indicators	Standardized loadings (*t*-Value)		Composite reliability (Variance extracted)		Configural invariance	Metric invariance
		Males	Females	Males	Females		Full:
C1	***Cronbach's α***	0.71	0.74	0.90 (0.81)	0.89 (0.80)	χ^2 = 1580.74	χ^2 = 1597.04
	X1	0.87 (41.71)	0.90 (46.90)				
	X2	0.93 (50.94)	0.90 (53.56)				
C2	***Cronbach's α***	0.72	0.72	0.93 (0.87)	0.90 (0.82)	df = 274	df = 293
	X3	0.88 (40.42)	0.87 (45.10)				
	X4	0.98 (48.90)	0.94 (51.82)				p = 0.00
C3	***Cronbach's α***	0.65	0.63	0.85 (0.5)	0.84 (0.50)	p = 0.00	
	X5	0.81 (34.95)	0.82 (36.27)				
	X6	0.88 (48.00)	0.85 (47.78)				$RMSEA$ = 0.065
	X7	0.69 (27.16)	0.65 (25.28)			$RMSEA$ =0.067	
	X8	-0.68 (24.53)	-0.68 (24.82)				$CAIC$ = 2349.90
C4	***Cronbach's α***	0.66	0.66	0.91 (0.64)	0.90 (0.61)	$CAIC$ =2498.01	
	X9	0.76 (33.41)	0.73 (32.77)				CFI = 0.96
	X10	0.77 (34.03)	0.73 (33.19)			CFI = 0.96	
	X11	-0.97 (72.56)	-0.97 (71.64)				$NNFI$ = 0.95
	X12	0.89 (56.60)	-0.89 (57.02)			$NNFI$ =0.95	
C5	***Cronbach's α***	0.89	0.88	0.98 (0.95)	0.96 (0.92)		
	X13	0.96 (43.32)	1.00 (48.13)				
	X14	1.00 (48.97)	0.94 (49.66)				
C6	***Cronbach's α***	0.76	0.73	0.85 (0.65)	0.83 (0.61)		
	X15	0.85 (48.04)	0.86 (47.07)				
	X16	0.82 (39.29)	0.78 (37.17)				
	X17	-0.74 (29.12)	-0.70 (27.46)				
	X18	-0.83 (40.89)	-0.79 (38.81)				
	X19	0.74 (30.58)	0.72 (28.65)				

Note: RMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Table 8 Reliability of the standardized Multi-Group Confirmatory Factor Analysis (age segmentation).

Construct	Indicators	Standardized loadings (*t*-Value)			Composite reliability (Variance extracted)			Configural invariance	Metric invariance	
		18-35	36-56	+56	18-35	36-56	+56		Full:	Partial:
C1	***Cronbach's α***	0.71	0.67	0.75	0.88 (0.78)	0.90 (0.82)	0.92 (0.85)	χ^2 = 1909.70	χ^2 = 2044.40	χ^2 = 1956
	X1	0.91 (37.87)	0.85 (39.69)	0.90 (41.57)						
	X2	0.86 (38.36)	0.96 (43.37)	0.94 (44.01)						
C2	***Cronbach's α***	0.68	0.67	0.75	0.89 (0.80)	0.92 (0.84)	0.93 (0.87)	df = 411	df = 449	df = 439
	X3	0.89 (33.10)	0.85 (32.52)	0.87 (36.28)						
	X4	0.89 (33.56)	0.98 (38.32)	0.99 (40.84)						
C3	***Cronbach's α***	0.65	0.66	0.60	0.86 (0.6)	0.88 (0.6)	0.82 (0.5)			
	X5	0.84 (29.71)	0.80 (28.60)	0.76 (24.28)				p = 0.00	p = 0.00	p = 0.00
	X6	0.88 (41.26)	0.93 (41.04)	0.83 (33.26)						
	X7	0.69 (24.64)	0.73 825.73)	0.70 (21.62)				*RMSEA* =0.072	*RMSEA* = 0.071	*RMSEA* = 0.07
	X8	-0.67 (22.13)	-0.73 (23.71)	-0.60 (17.57)						
C4	***Cronbach's α***	0.60	0.68	0.69	0.88 (0.54)	0.95 (0.75)	0.90 (0.61)			
	X9	0.65 (22.08)	0.82 (29.67)	0.72 (23.42)				*CAIC* =3285.61	*CAIC* = 3091.47	*CAIC* =3090.4
	X10	0.65 (22.03)	0.88 (30.97)	0.74 (24.15)						
	X11	-0.96 (59.23)	-0.99 (62.56)	-0.94 (52.62)						
	X12	-0.89 (50.35)	-0.90 (50.85)	-0.91 (43.17)				*CFI* = 0.96	*CFI* = 0.96	*CFI* = 0.96
C5	***Cronbach's α***	0.84	0.91	0.89	0.96 (0.93)	0.98 (0.96)	0.99 (0.99)			
	X13	0.96 (31.75)	0.96 (37.92)	1.01 (34.95)						
	X14	0.97 (34.00)	1 (42.17)	1.00 (34.02)				*NNFI* =0.95	*NNFI* =0.95	*NNFI* =0.95
C6	***Cronbach's α***	0.74	0.75	0.75	0.85 (0.66)	0.83 (0.62)	0.83 (0.62)			
	X15	0.89 (49.46)	0.86 (45.98)	0.85 (40.84)						
	X16	0.81 (34.92)	0.78 (32.95)	0.79 (30.28)						
	X17	-0.72 (23.95)	-0.72 (23.85)	-0.72 (21.42)						
	X18	-0.79 (33.15)	-0.87 (35.46)	-0.77 (28.64)						
	X19	0.73 (27.06)	0.75 (27.59)	0.75 (24.19)						

Note: RMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Table 9 Reliability of the standardized Confirmatory Factor Analysis (consumer intentions towards GMF).

Construct	**Indicators**	**Standardized loadings (*t*-Value)**		**Composite reliability (Variance extracted)**		**Configural invariance**	**Metric invariance**	
		Willing to consume GMF	Not Willing to consume GMF	Willing to consume GMF	Not Willing to consume GMF		Full:	Partial:
C1	***Cronbach's α***	0.75	0.70	0.88 (0.79)	0.88 (0.79)	χ^2 = 1454.97 df = 274 p = 0.00 *REMSEA* =0.067 *CAIC* =2363.60 *CFI* = 0.97 *NNFI* =0.96	χ^2 = 1606.95 df = 293 p = 0.00 *REMSEA* = 0.068 *CAIC* = 2352.71 *CFI* = 0.96 *NNFI* = 0.95	χ^2 = 1478.53 df = 289 p = 0.00 *REMSEA* = 0.065 *CAIC* = 2258.58 *CFI* = 0.96 *NNFI* =0.96
	X1	0.94 (39.32)	0.85 (46.84)					
	X2	0.93 (46.85)	0.93 (58.97)					
C2	***Cronbach's α***	0.72	0.71	0.90 (0.82)	0.90 (0.82)			
	X3	0.89 (29.81)	0.87 (42.92)					
	X4	0.96 (38.98)	0.94 (56.87)					
C3	***Cronbach's α***	0.62	0.63	0.81 (0.50)	0.81 (0.50)			
	X5	0.83 (29.11)	0.76 (34.61)					
	X6	0.81 (34.01)	0.84 (42.67)					
	X7	0.66 (21.42)	0.64 (24.96)					
	X8	-0.77 (23.53)	-0.63 (24.40)					
C4	***Cronbach's α***	0.64	0.64	0.89 (0.57)	0.89 (0.57)			
	X9	0.73 (26.86)	0.72 (34.07)					
	X10	0.83 (29.10)	0.71 (32.25)					
	X11	-0.92 (50.84)	-0.95 (66.76)					
	X12	-0.89 (40.32)	-0.86 (51.77)					
C5	***Cronbach's α***	0.79	0.90	0.97 (0.93)	0.97 (0.93)			
	X13	1.01 (34.66)	0.99 (33.23)					
	X14	1.00 (36.95)	0.94 (36.03)					
C6	***Cronbach's α***	0.67	0.68	0.75 (0.51)	0.75 (0.51)			
	X15	0.81 (28.19)	0.74 (32.86)					
	X16	0.70 (21.92)	0.73 (31.21					
	X17	-0.62 (18.37)	-0.66 (23.86)					
	X18	-0.87 (26.59)	-0.71 (28.67)					
	X19	0.69 (21,43)	0.75 (29.81)					

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Table 10 Reliability of the standardized Confirmatory Factor Analysis (GM-free and producer regions).

Construct	Indicators	Standardized loadings (*t*-Value)		Composite reliability (Variance extracted)		Configural invariance	Metric invariance	
		GM free region	GM producer region	GM free region	GM producer region		Full:	Partial:
C1	***Cronbach's α***	0.71	0.74	0.90 (0.81)	0.92 (0.85)	χ^2 = 1497.11 df = 274 p = 0.00 *RMSEA* =0.064 *CAIC* =2418.62 *CFI* = 0.96 *NNFI* =0.95	χ^2 = 1611.51 df = 293 p = 0.00 *RMSEA* = 0.064 *CAIC* = 2367.84 *CFI* = 0.96 *NNFI* = 0.95	χ^2 = 1551.77 df = 287 p = 0.00 *RMSEA* = 0.063 *CAIC* =2360.26 *CFI* = 0.96 *NNFI* =0.95
	X1	0.87 (52.11)	0.91 (57.08)					
	X2	0.93 (55.29)	0.90 (58.14)					
C2	***Cronbach's α***	0.73	0.71	0.96 (0.92)	0.89 (0.80)			
	X3	0.92 (40.40)	0.88 (39.75)					
	X4	0.99 (48.38)	0.91 (46.40)					
C3	***Cronbach's α***	0.66	0.64	0.87 (0.60)	0.82 (0.50)			
	X5	0.87 (34.39)	0.76 (32.81)					
	X6	0.89 (41.22)	0.82 (40.73)					
	X7	0.65 (24.50)	0.68 (27.48)					
	X8	-0.76 (26.88)	-0.65 (25.42)					
C4	***Cronbach's α***	0.68	0.64	0.93 (0.70)	0.88 (0.55)			
	X9	0.79 (32.41)	0.67 (29.23)					
	X10	0.85 (34.75)	0.70 (30.48)					
	X11	-0.95 (66.05)	-0.94 (68.26)					
	X12	-0.90 (54.29)	-0.88 (56.99)					
C5	***Cronbach's α***	0.89	0.88	0.99 (0.97)	0.96 (0.92)			
	X13	0.98 (41.91)	1.01 (48.16)					
	X14	0.99 (49.61)	0.92 (46.21)					
C6	***Cronbach's α***	0.75	0.74	0.86 (0.67)	0.81 (0.59)			
	X15	0.91 (44.35)	0.82 (43.29)					
	X16	0.83 (36.81)	0.75 (36.43)					
	X17	-0.69 (27.29)	-0.74 (31.03)					
	X18	0.80 (36.70)	-0.81 (42.07)					
	X19	0.67 (27.46)	0.75 (33.08)					

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Table 11 Goodness-of-fit for the structural regression models

	Full	18-35	36-56	+56	WTC	NWTC	GMfree	GM producer	Male	Female
χ^2_{df}	1326.80	704.10	695.38	669.41	658.97	953.05	743.61	853.73	812.21	851.69
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
REMSEA	0.062	0.070	0.070	0.070	0.070	0.060	0.066	0.063	0.067	0.069
GFI	0.98	0.97	0.98	0.97	0.98	0.98	0.98	0.98	0.98	0.97
AGFI	0.97	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.96
CFI	0.95	0.94	0.96	0.96	0.97	0.95	0.96	0.96	0.96	0.94
NFI	0.94	0.92	0.95	0.95	0.96	0.94	0.95	0.95	0.96	0.93
NNFI	0.94	0.93	0.96	0.95	0.97	0.94	0.96	0.95	0.96	0.93

REMSEA <0.5-0.8 (Browne and Cudeck, 1992; Kline, 207) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

FIGURES

Figure 1. Consumer conceptual process of acceptance

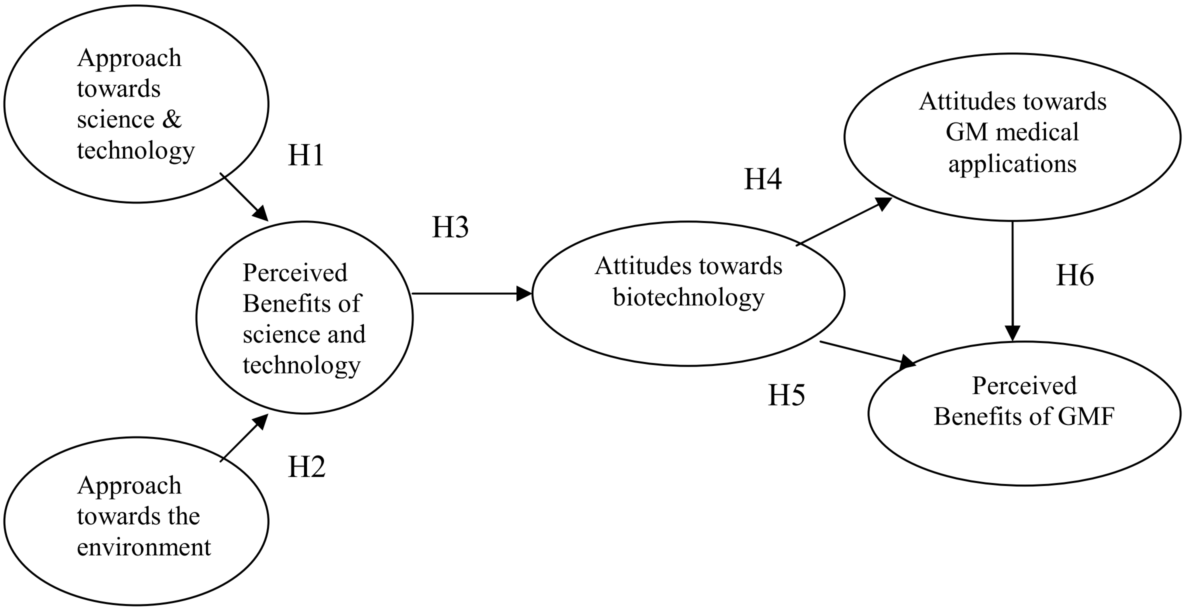
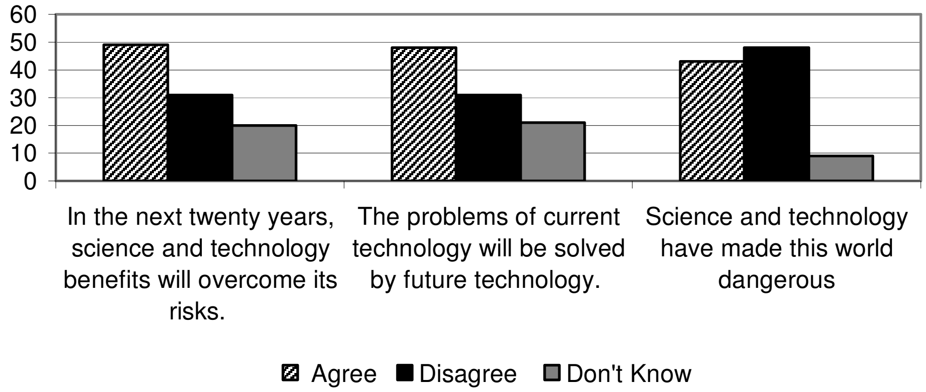
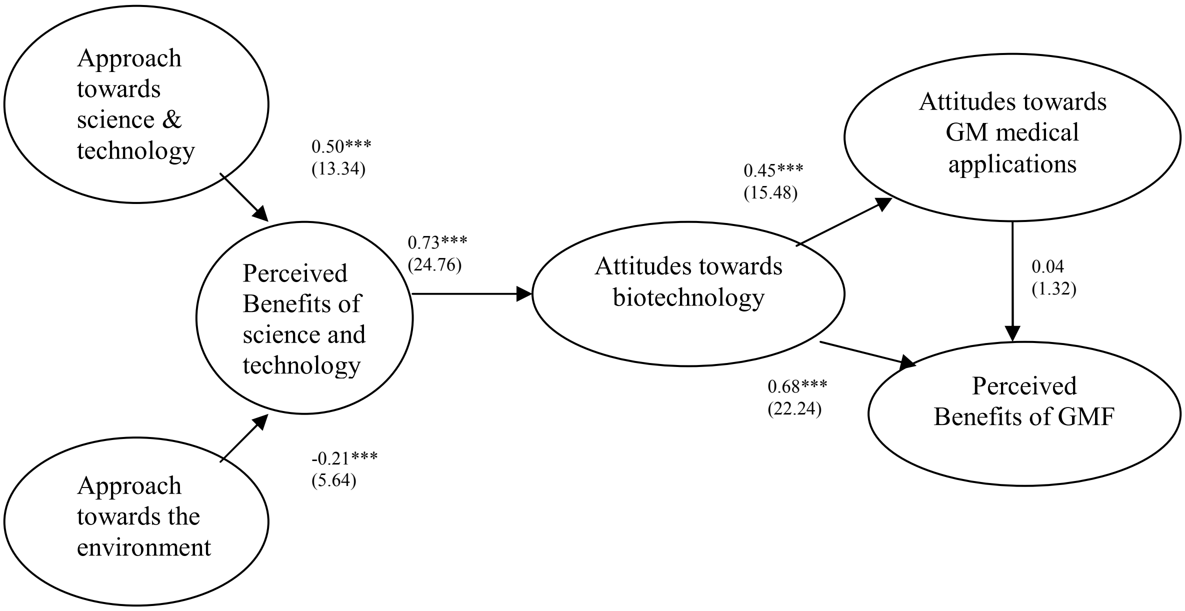


Figure 2. Public benefit perceptions of science and technology.



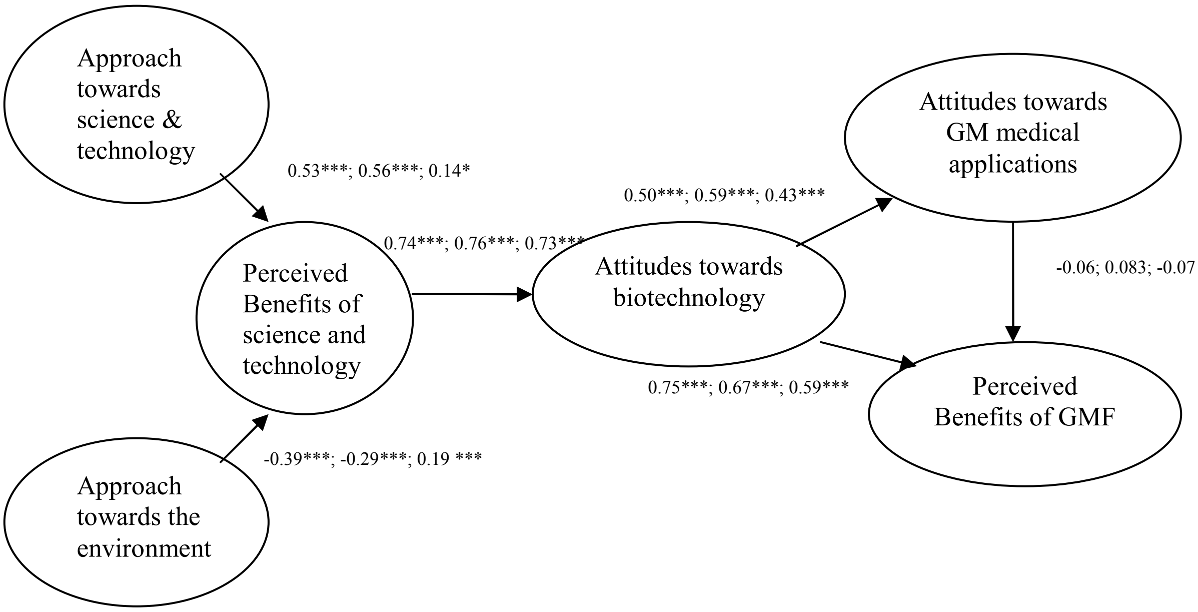
Question: Now I will read you some opinions on science and technology, and would like you to tell me if you agree or disagree with them.

Figure 3. Path diagram results Spanish full sample



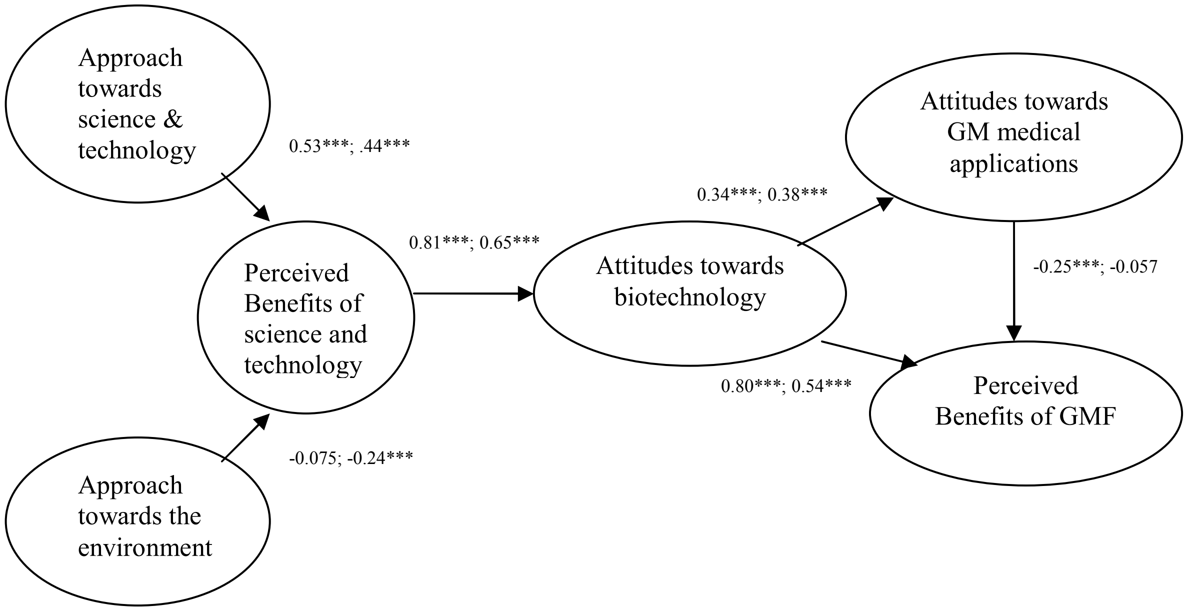
* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 4. Path diagram results Spanish age segmented sample (18-35; 36-56; +56)



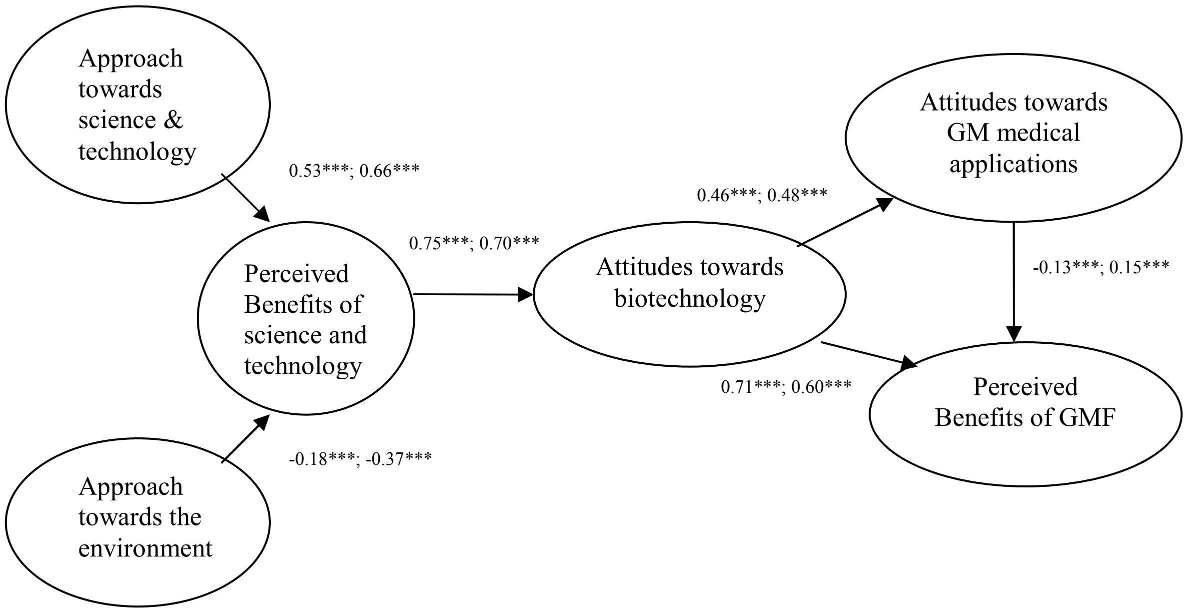
* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 5. Path diagram results Spanish consumer intentions towards GM food segmented sample (willing to consume; not willing to consume)



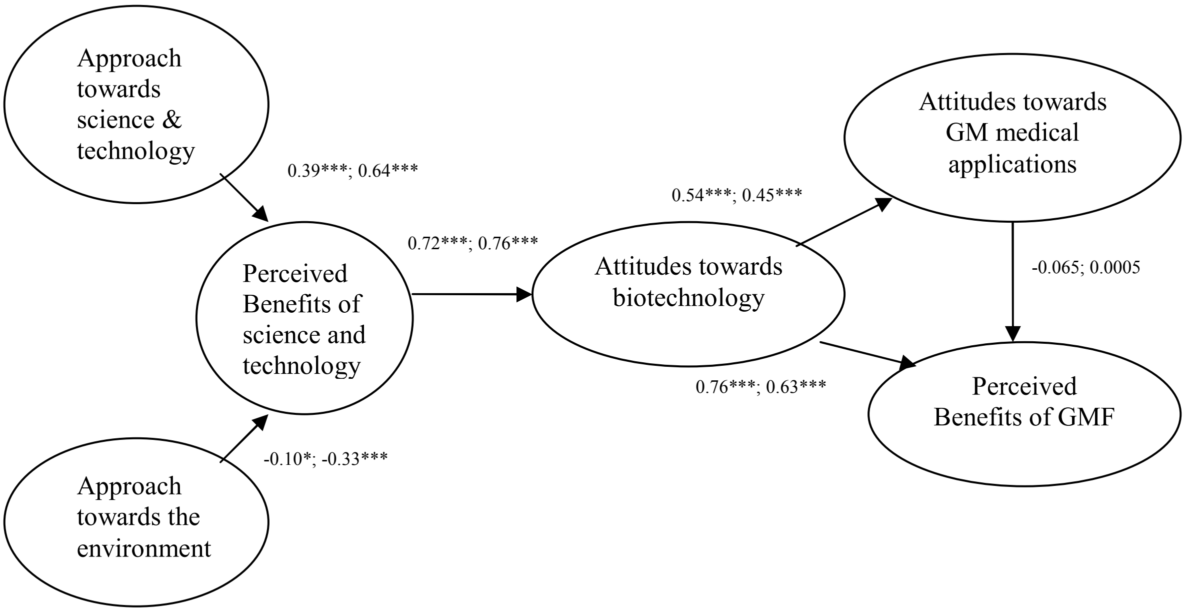
* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 6. Path diagram results Spanish GM producer region segmented sample (GM producer; GM free)



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 7. Path diagram results Spanish segmented sample by gender (male; female)



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$